

WHAT IS CLAIMED IS:

- 1 1. A method for forming a dense Si-C-B-N composite, said method
2 comprising:
3 (a) mechanically activating a powder mixture comprised of silicon nitride,
4 silicon carbide, and boron nitride; and
5 (b) consolidating said powder mixture into a continuous mass by compressing
6 said powder mixture in the presence of 0 to 1% by weight of metal oxide densification
7 aids relative to said powder mixture, while passing an electric current through said
8 powder mixture, to achieve a fused Si-C-B-N mass comprised of crystals less than
9 100 nanometers in diameter.
- 1 2. The method of claim 1 wherein said powder mixture is substantially
2 amorphous.
- 1 3. The method of claim 1 wherein said crystals of said fused Si-C-B-N
2 mass are less than 50 nm in diameter.
- 1 4. The method of claim 1 wherein any metal densification aid present in
2 step (b) is from 0 to 0.5% by weight of said powder mixture.
- 1 5. The method of claim 1 wherein any metal densification aid present in
2 step (b) is from 0 to 0.1% by weight of said powder mixture.
- 1 6. The method of claim 1 wherein step (b) is performed in the absence of
2 metal oxide densification aids.
- 1 7. The method of claim 1 wherein said powder mixture consists
2 essentially of from about 10 to about 60 parts by volume silicon, from about 10 to about 60
3 parts by volume carbon, from about 10 to about 60 parts by volume nitrogen, and from about
4 2 to about 30 parts by volume boron, based on a total of 100 parts by volume of said powder
5 mixture.
- 1 8. The method of claim 1 further comprising forming said powder
2 mixture by combining decaborane with a polyorganosilazane, followed by crosslinking and
3 pyrolysis.

- 1 **9.** The method of claim 8 wherein said polyorganosilazane is a
2 polyureasilazane.
- 1 **10.** The method of claim 1 wherein step (b) comprises compressing said
2 powder mixture at a pressure of about 10 MPa to about 200 MPa and a temperature of about
3 900°C to about 3,000°C, and said electric current is a pulsed direct current of about
4 1,000 A/cm² to about 10,000 A/cm².
- 1 **11.** The method of claim 10 wherein said pressure is about 40 MPa to
2 about 100 MPa.
- 1 **12.** The method of claim 10 wherein said temperature is about 1,000°C to
2 about 2,000°C.
- 1 **13.** The method of claim 10 wherein said pulsed direct current is about
2 1,500 A/cm² to about 5,000 A/cm².
- 1 **14.** The method of claim 1 wherein step (b) is performed to achieve a
2 fused mass with a density of at least 95% relative to a volume-averaged theoretical density.
- 1 **15.** The method of claim 1 wherein step (b) is performed to achieve a
2 fused mass with a density of at least 98% relative to a volume-averaged theoretical density.
- 1 **16.** The method of claim 1 wherein step (b) is performed to achieve a
2 fused mass with a density of at least 99% relative to a volume-averaged theoretical density.
- 1 **17.** The method of claim 1 wherein step (a) comprises milling said powder
2 mixture by high-energy ball milling.
- 1 **18.** The method of claim 17 wherein said high-energy ball milling is
2 performed with silicon nitride milling balls in an oscillating mill at about 6 or more impacts
3 per second and a charge ratio of at least about 10:4.
- 1 **19.** A dense composite of silicon nitride, silicon carbide, and boron nitride,
2 consisting essentially of crystals less than 100 nm in diameter and containing 0 to 1% by
3 weight of metal oxide densification aids, produced by a process comprising:

4 (a) mechanically activating a powder mixture of silicon nitride, silicon
5 carbide, and boron nitride; and

6 (b) consolidating said powder mixture into a continuous mass by compressing
7 said powder mixture in the presence of 0 to 1% by weight of metal oxide densification
8 aids while passing an electric current through said powder mixture, to achieve a fused
9 Si-C-B-N mass comprised of crystals less than 100 nanometers in diameter.

1 20. The composite of claim 19 wherein said powder mixture of step (a) is
2 substantially amorphous.

1 21. The composite of claim 19 wherein said fused mass consists of
2 particles less than 50 nanometers in diameter.

1 22. The composite of claim 19 wherein step (b) is performed in the
2 presence of 0 to 0.5% by weight of metal oxide densification aids.

1 23. The composite of claim 19 wherein step (b) is performed in the
2 presence of 0 to 0.1% by weight of metal oxide densification aids.

1 24. The composite of claim 19 wherein step (b) is performed in the
2 absence of metal oxide densification aids.

1 25. The composite of claim 19 wherein said powder mixture consists
2 essentially of from about 10 to about 60 parts by volume silicon, from about 10 to about 60
3 parts by volume carbon, from about 10 to about 60 parts by volume nitrogen, and from about
4 2 to about 30 parts by volume boron, totaling 100 parts by volume of said powder mixture.

1 26. The composite of claim 19 wherein said powder mixture is formed by
2 combining decaborane with a pyrolysis product of a polyorganosilazane in an inert
3 atmosphere.

1 27. The composite of claim 26 wherein said polyorganosilazane is a
2 polyureasilazane.

1 28. The composite of claim 19 wherein step (b) comprises compressing
2 said powder mixture at a pressure of about 10 MPa to about 200 MPa and a temperature of

3 about 900°C to about 3,000°C, and said electric current is a pulsed direct current of about
4 1,000 A/cm² to about 10,000 A/cm².

1 29. The composite of claim 28 wherein said pressure is about 40 MPa to
2 about 100 MPa.

1 30. The composite of claim 28 wherein said temperature is about 1,000°C
2 to about 2,000°C.

1 31. The composite of claim 28 wherein said pulsed direct current is about
2 1,500 A/cm² to about 5,000 A/cm².

1 32. The composite of claim 19 wherein step (b) is performed to achieve a
2 fused mass with a density of at least 95% relative to a volume-averaged theoretical density.

1 33. The composite of claim 19 wherein step (b) is performed to achieve a
2 fused mass with a density of at least 98% relative to a volume-averaged theoretical density.

1 34. The composite of claim 19 wherein step (b) is performed to achieve a
2 fused mass with a density of at least 99% relative to a volume-averaged theoretical density.

1 35. The composite of claim 19 wherein step (a) comprises milling said
2 powder mixture by high-energy ball milling.

1 36. The composite of claim 19 wherein said high-energy ball milling is
2 performed with silicon nitride milling balls in an oscillating mill at about 6 or more impacts
3 per second and a charge ratio of at least about 10:4.